Concrete Floors for Residences

Concrete for Permanence and Firesafety

Published by

PORTLAND CEMENT ASSOCIATION

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A National Organization to Improve and Extend the Uses of Concrete

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Concrete Floors for Residences

REINFORCED concrete floors in residences offer an exceptional appeal to the modern buyer. Realtors and building contractors have noticed a marked tendency on the part of home buyers to insist on better construction just as they consistently demand the most modern conveniences. In communities where it has been difficult to sell residences of ordinary construction, builders of permanent, fireproof houses have found a ready market.

In hotels, apartments, schools, hospitals, garages, office, mercantile and industrial buildings, the successful performance of reinforced concrete floors over a long period of years has established this construction as a guarantee of rigidity, durability, firesafety and beauty. It is logical that this material — reinforced concrete — should be selected for residence floor construction.

Concrete Floors Reduce Upkeep Costs

Lack of rigidity in floors with consequent sagging or other movement is responsible for most plaster cracks in dwellings. Likewise, floors that are subject to movement are responsible for doors and windows being out of plumb, cracks in wood flooring, and countless other structural defects that are commonly found in the average house. Concrete residence floors are free from sagging, deflection or lateral movement and eliminate plaster cracking on walls and ceilings and minimize redecorating costs. In addition, concrete floors reduce vibration caused by heavy city traffic or by movement within the residence. Stability, a feature of particular importance in areas subject to windstorms or earthquakes, is also assured by concrete floors. Termites, which in certain parts of the country destroy ordinary types of floors, are repelled by concrete. Furthermore, concrete floors do not decay; their strength and durability increase with age.

Concrete Floors Are Fireproof

For many years concrete has been the accepted material for fireproof construction. Countless tests — in laboratories, in actual fires and in fire demonstrations — have proved that concrete will successfully withstand intense heat. These tests have justified the extensive use of concrete in all types of fireproof construction. Especially in floors is this true. Incombustible floors prevent the spread of fire from one story to another and confine a fire to its place of origin. Statistics show that a large percentage of residence fires originate in the basement where they gain headway rapidly and often envelope the house in flames before being discovered. Concrete first floors eliminate the peril of such fires by confining them to the place where they start.

Easy to Build

With ordinary equipment concrete residence floors are easy to build. The essential requirements, as outlined in this booklet, include an approved floor design, ordinary skill in form building and a general knowledge of good concrete construction. Once a contractor builds a few reinforced concrete residence floors he finds that the work can be made as simple as average foundation construction. Builders also find that they can construct rigid, durable, fireproof concrete floors at a comparatively small additional cost over ordinary construction.

To enable architects and contractors to meet the home builders' demands for fireproof floors of concrete, the Portland Cement Association has assembled and published this booklet of correct construction information. Precast concrete joist, solid slab, tile and joist, concrete joist and steel beam-concrete residence floors are described in detail, with drawings showing typical designs and construction methods. Designs and form details for reinforced concrete beams and columns also are included to help contractors build these structural parts.

The methods for developing and laying the various types of floor finishes and floor coverings are discussed, with illustrations showing typical surfaces including concrete and ceramic tile, terrazzo, art marble, slate, linoleum, rubber, cork and wood flooring as well as surfaces in which character and beauty have been developed in the concrete slab itself or in a concrete topping.

Precast Joist Concrete Floor Construction

PRECAST joists of reinforced concrete support a concrete slab in this type of fireproof floor construction for residences. According to contractors who have used it, this is one of the most economical methods for building concrete residence floors.

The maximum unsupported span, as shown in the typical design on page 5, may vary from 16 to 24 feet, depending upon the size of joists used and their spacing. Longer spans require interior supports—bearing partitions or reinforced concrete beams as shown in the Longitudinal Section on page 5. Also, a bearing wall or beam is required under any first floor partition which carries a load from the second floor.

Precast concrete joists handle easily and carry required loads

If required, intermediate bearing walls or beams and columns are built first. Reinforced concrete beams and columns are shown in detail on pages 15 and 17.

When foundation walls and other supports that may be required are completed, the precast concrete joists are set in place—generally 24 to 33 inches on center, depending upon the floor design—and then the simple formwork for the floor slab is placed. Joists must have a minimum bearing of 4 inches on foundation walls and bearing partitions. Forms consist of 1-inch form boards or plywood between joists, spreaders, wedges and planks, as shown in the drawing on page 5.

For spans longer than 16 feet, it is recommended that the precast concrete joists be supported temporarily at mid-span with posts and stringers to prevent excessive deflection while the concrete for the slab is being placed. For shorter spans no supports are required.

Where a smooth ceiling is desired, the 1-inch form boards are covered with heavy building paper as shown in the drawing. Forms are so built that the finished concrete slab will be 2 to 2½ inches in thickness.

Placing Reinforcement

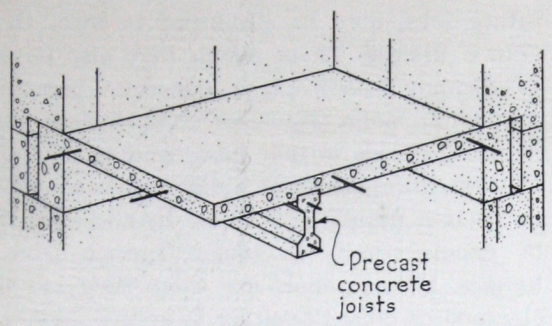
With joists and formwork in place, reinforcing steel is set. This consists of ¼-inch round bars, 18 inches on center, parallel to the joists; ¼-inch round bars, 10 inches on center, at right angles to the joists, or large mesh metal reinforcement of equivalent effective area. Placing reinforcement directly on top of the joists holds it the required ¾-inch above the forms.

View of underside of fireproof floor built with precast joists.

Precast concrete joists, of course, are reinforced, this having been taken care of by the manufacturer. As shown in the drawing, there are several alternate methods of reinforcement for joists.

For detailed information on design and construction, see the Portland Cement Association booklet, "The Design and Construction of Precast Joist Concrete Floors."

Designing, mixing, placing and curing of concrete and the removal of forms are discussed in detail on pages 22, 23 and 24.

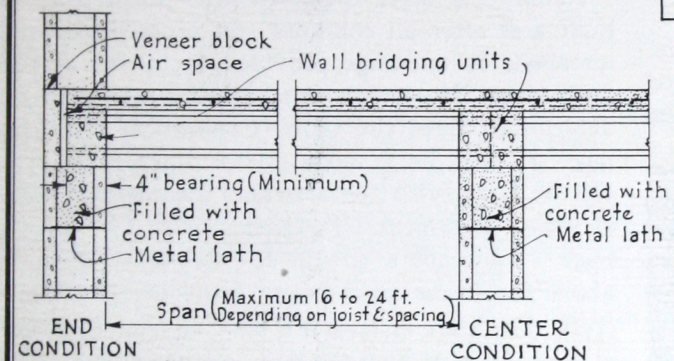


PERSPECTIVE

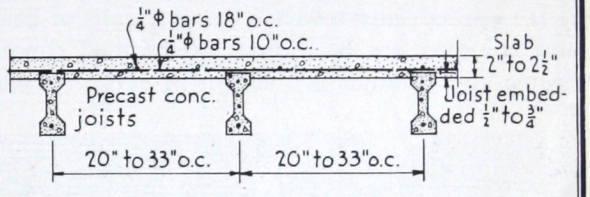
NOTES

1. Concrete shall have a minimum compressive strength at 28 days as follows:
   Concrete in joists - 3000 lb. per sq. in.
   Concrete in slab - 3000 lb. per sq. in. *
2. Structural floor plans shall conform to the joist manufacturers specifications and shall be approved by the owners architect. These plans shall show the joist sizes, spacing and other framing details; slab thickness and reinforcement.
3. Design loadings shall conform to those recommended by the Building Code Committee - U. S. Dept. of Commerce and/or the local building regulations.
4. Bearing partitions must be carried by walls or by beams and columns below.
5. Design and construction details must provide for an adequate bond of the slab to the joist.
6. Joists may be doubled to serve as trimmers and headers around stairwells, to support non-bearing partitions or wherever loading conditions may require.

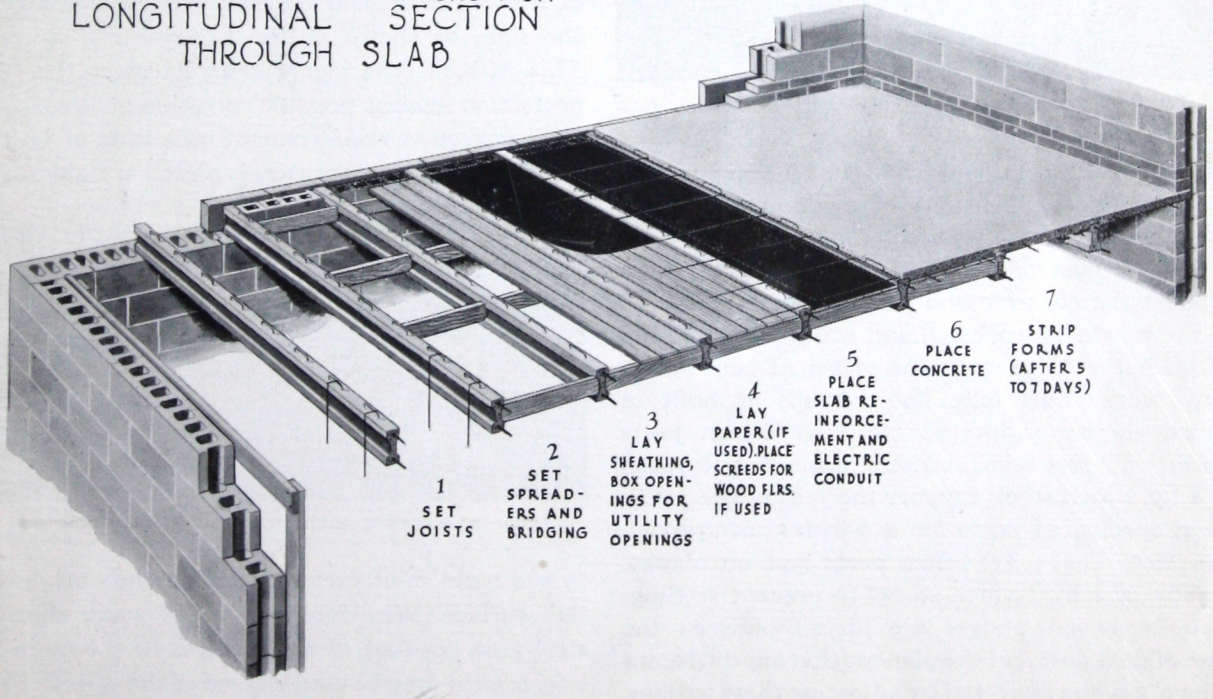
*(6 gal. of water per sack of cement)



LONGITUDINAL SECTION THROUGH SLAB



CROSS SECTION



PRECAST JOIST CONCRETE RESIDENCE FLOOR

Solid Slab Floor Construction

THE solid slab concrete residence floor, as its name implies, is a reinforced concrete slab of uniform thickness extending over the entire floor area. A 6-inch thickness of slab is generally suitable for spans up to 16 feet in length.

In the typical design shown on page 7 the unsupported span is limited to 16 feet. Longer spans require interior supports — bearing partitions or reinforced concrete beams as shown in the Longitudinal Section on page 7. Also, a bearing wall or beam of the same design is required under any first floor partition which carries a load from the second floor.

If required, intermediate bearing walls or beams and columns are built first. Reinforced concrete beams and columns are shown in detail on pages

Reinforced concrete first floor of the solid slab type.

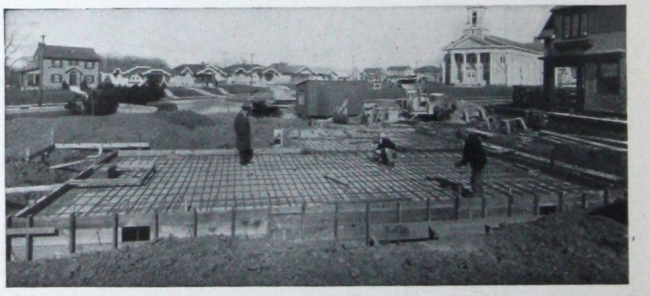
15 and 17. Posts and stringers for supporting the false floor, which may be made up of shiplap or standard panels, are erected next.

A tight false floor having sufficient strength to support the concrete and reinforcing steel as well as the weight of workmen and equipment required to place the concrete is the principal part of the form work. This false floor usually is built of 1-inch shiplap supported by 2 by 6-inch joists placed on 2 feet 6-inch centers. Posts and stringers of 4 by 4-inch stock support the joists. The maximum spacing of posts for a 6-inch concrete slab is 4 feet. The 4 by 4-inch posts rest on planks, usually of 2 by 10-inch stock, to prevent settling. Two hardwood wedges are placed between the base of each post and the plank so that any difference in level may be corrected by adjusting these wedges. Forms for solid slab construction are pictured on page 7.

Panels of standard size, which can be used on future jobs, may be employed to form the false floor if desired. These panels may also be utilized in forming cast-in-place concrete basement or foundation walls. However, the principal economy in using panels is that labor and time are saved in dismantling and rebuilding when forms are to be used a number of times. In addition, the use of panels results in longer service from form lumber. When panels are used, they are usually clamped or bolted together to secure greater rigidity and accurate position.

Reinforcing steel is placed after form work is built and after all conduits and pipes have been installed, or openings provided for them in the floor slab. Size and spacing of the steel can be determined from the table, Reinforcing Bars, on page 7. The bars should be supported ¾-inch off the floor, with the alternate bars bent 45 degrees as shown in the Longitudinal Section on page 7. The bars should be supported ¾-inch above the forms on chairs or small pieces of concrete. The ends of bars are bent so that they are at least ¾-inch from the top, bottom and edge of the slab, as shown in the Longitudinal Section. This ¾-inch covering of concrete gives the steel protection against possible corrosion or fire.

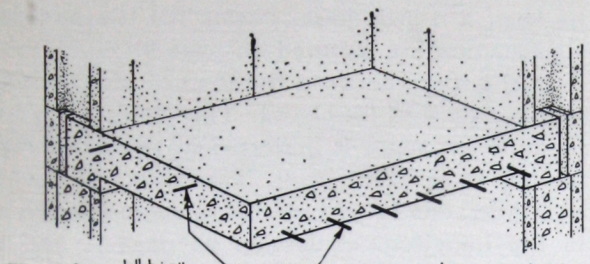
Temperature reinforcement consisting of ¼-inch steel bars on 12-inch centers is placed at right angles



Forms and reinforcing steel in place for solid slab concrete floor.

to the main reinforcement and ¾ inch below the slab surface. Wire fabric with the same effective steel area per foot at right angles to the main reinforcement may be used instead of the ¼-inch bars.

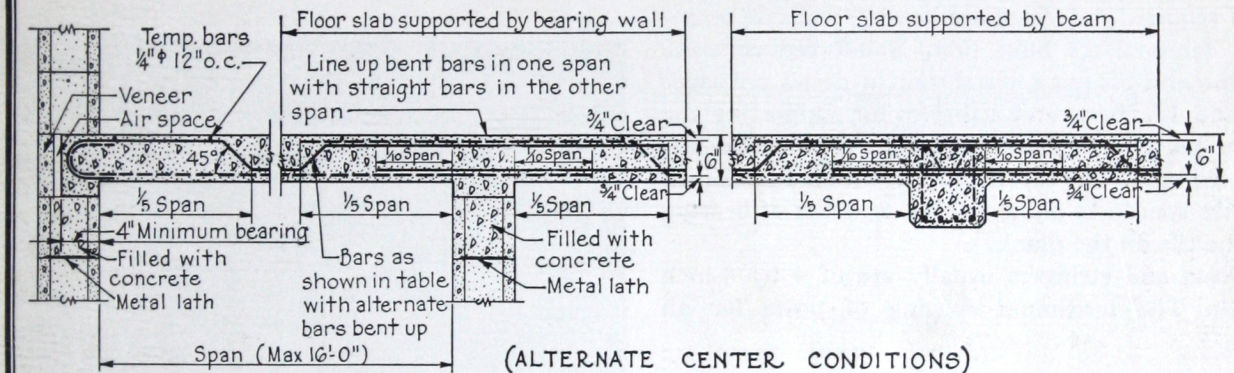
Designing, mixing, placing and curing of concrete and the removal of forms are discussed in detail on pages 22, 23 and 24.



PERSPECTIVE

NOTES

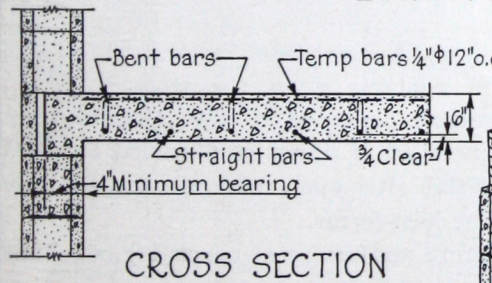
1. Designed for concrete with a compressive strength of not less than 2000 lb. per sq. in. at 28 days (7½ gal. of water per sack of cement.)
2. Designed according to Building Regulations of the American Concrete Institute, 1928.
3. Loadings are those recommended for Residences by the Building Code Committee of the United States Department of Commerce.
4. Bearing partitions must be carried by walls or by beams and columns below.
5. Steel reinforcement must be accurately located and held in place. All intersections must be tied with No. 18 annealed wire.
6. Wire fabric with the same effective area per foot may be used instead of temperature bars.
7. Extra reinforcement is required around stairwells.



(END CONDITION)

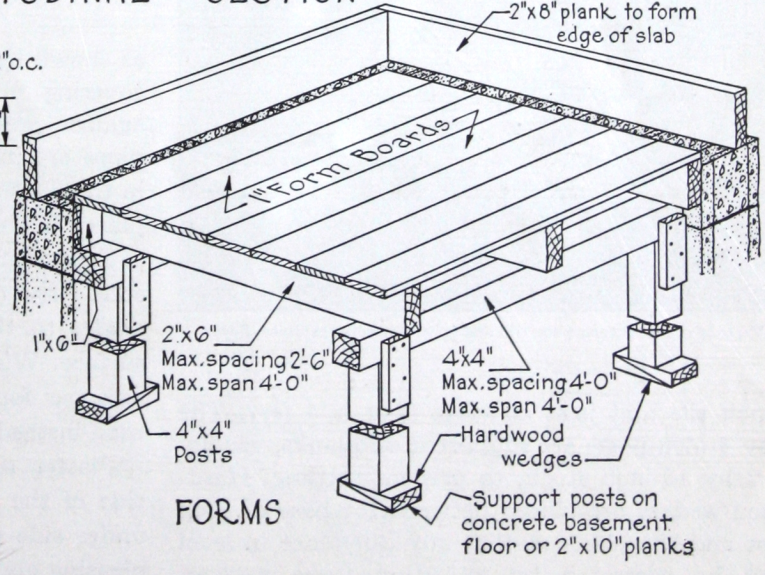
(ALTERNATE CENTER CONDITIONS)

LONGITUDINAL SECTION



CROSS SECTION

REINFORCING BARS		
Span	Size	Spacing
16'-0" to 14'-0"	⅝" ϕ	5"
14'-0" to 12'-0"	½" ϕ	6"
12'-0" to 10'-0"	½" ϕ	8"
10'-0" or less	⅜" ϕ	7"



FORMS

SOLID SLAB CONCRETE RESIDENCE FLOOR

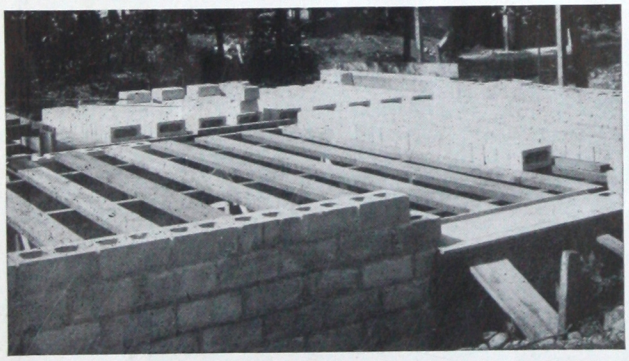
Tile and Joist Floor Construction

THIS type of residence floor consists of a combination of hollow concrete tile or block and reinforced concrete joists. Joists not less than 4 inches wide and 6 inches deep, with a top slab not less than 2 inches thick, are recommended for spans up to 16 feet in length.

In the typical design shown on page 9 the unsupported span is limited to 16 feet. Longer spans require interior supports — bearing partitions or reinforced concrete beams as shown in the Longitudinal Section on page 9. Also, a bearing wall or beam of the same design is required under any first floor partition which carries a load from the second floor.

If required, intermediate bearing walls or beams and columns are built first. Reinforced concrete beams and columns are shown in detail on pages 15 and 17. Posts and stringers for supporting the open centering (planks which carry the tile) are erected next. The tile are supported on 2 by 8-inch planks spaced to allow at least 2 inches of bearing of the tile on the plank.

Posts and stringers usually are of 4 by 4-inch stock. The maximum spacing of posts for an



View of open-centering for tile and joist concrete residence floor.

8-inch tile and joist concrete floor is 4 feet. The 4 by 4-inch posts are supported on planks, usually of 2 by 10-inch stock, to prevent settling. Hardwood wedges are placed between the base of each post and the plank so that any difference in level may be corrected by adjusting these wedges. Briefly, the posts support the stringers and the stringers, in turn, support the 2 by 8-inch planks, allowing enough space between the rows of tile to form a 4-inch joist. Forms for tile and joist construction are pictured on page 9.

In the space between the rows of tile, the main reinforcing steel is placed. The size of the bars for different spans is indicated in the table, Reinforcing Bars, on page 9. Two bars are used in each joist, one being bent up 45 degrees, as shown in the Longitudinal Section on page 9, and the other remaining straight. The bars should be supported 1-inch above the plank and ¾-inch from the tile on chairs or small pieces of concrete. The ends of bars are bent so that they are at least 1-inch from the top, bottom and edge of the slab,

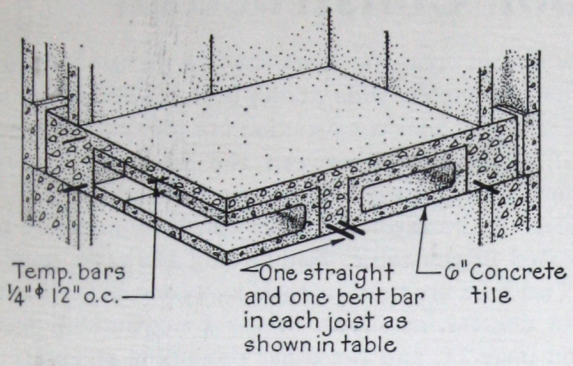
Building foundation walls and forms for tile and joist floor.

as shown in the Longitudinal Section. This 1-inch covering of concrete gives the steel protection against possible corrosion or fire. Conduits and pipes are installed or openings provided for them in the floor slab after main reinforcement has been placed in the joist forms.

Temperature reinforcement consisting of ¼-inch steel bars on 12-inch centers is placed at right angles to the joists and ¾ inch below the slab surface. Wire fabric with the same effective steel area per foot at right angles to the joists may be used instead of the ¼-inch bars.

Plaster may be applied directly to the under side of the floor, eliminating a hung ceiling. The under side of this type of floor frequently has a pleasing appearance without plastering.

Designing, mixing, placing and curing of concrete and the removal of forms are discussed in detail on pages 22, 23 and 24.



PERSPECTIVE

NOTES

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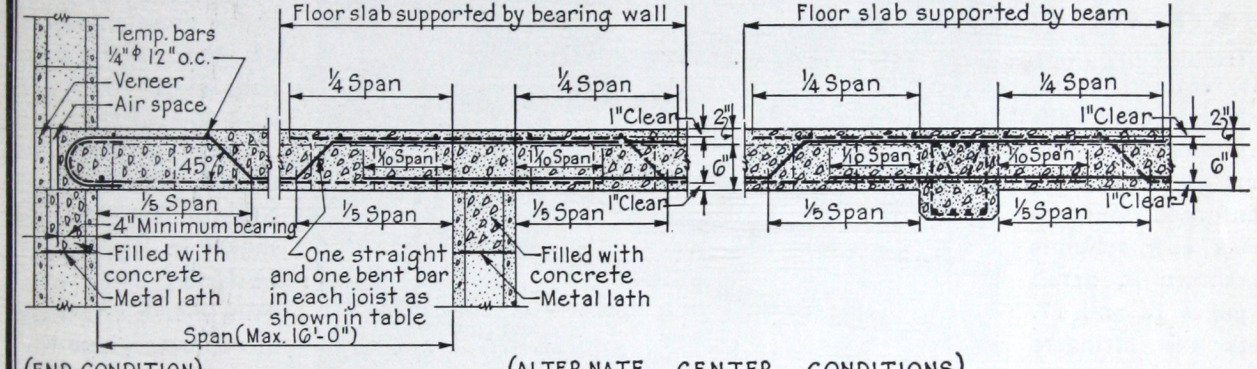
2. Designed according to Building Regulations of the American Concrete Institute, 1928.
3. Loadings are those recommended for Residences by the Building Code Committee of the United States Department of Commerce.
4. Bearing partitions must be carried by walls or by beams and columns below.
5. Steel reinforcement must be accurately located and held in place. All intersections must be tied with No. 18 annealed wire.
6. Wire fabric with the same effective area per foot may be used instead of temperature bars.
7. Extra reinforcement is required around stairwells.



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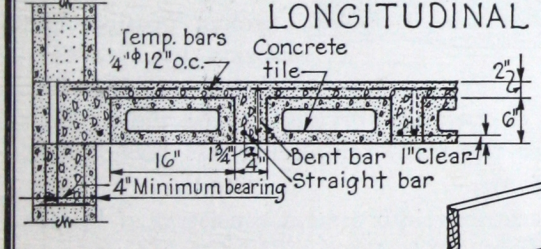
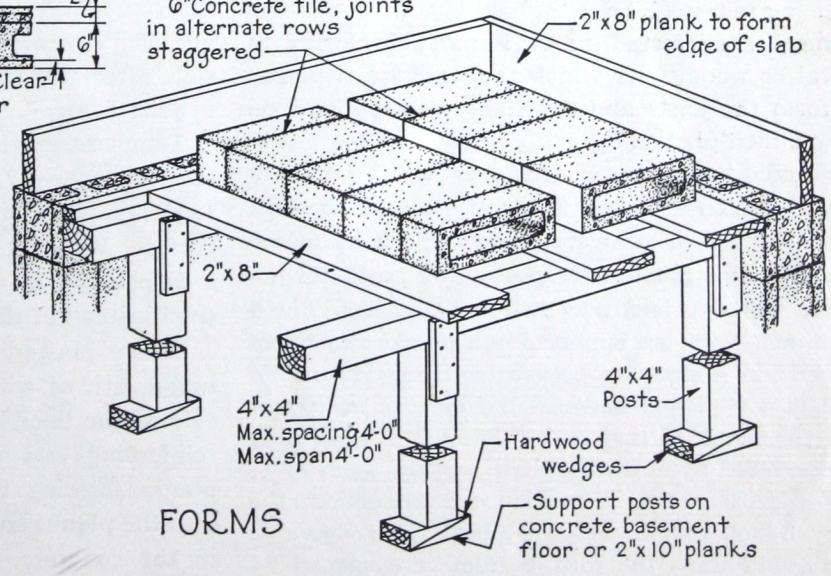
LONGITUDINAL SECTION THROUGH JOIST



CROSS SECTION

REINFORCING BARS		
Span	Bars per joist	
	Straight	Bent
16'-0" to 15'-0"	1-¾" ϕ	1-⅝" ϕ
15'-0" to 13'-0"	1-⅝" ϕ	1-⅝" ϕ
13'-0" or less	1-½" ϕ	1-½" ϕ



FORMS

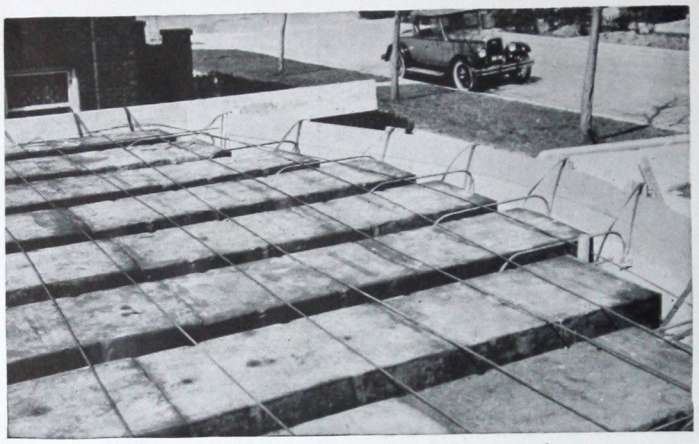
TILE AND JOIST CONCRETE RESIDENCE FLOOR

Concrete Joist Floor Construction

IN concrete joist residence floor construction a minimum of material is used. Joists not less than 4 inches wide and 6 inches deep, with a top slab not less than 2 inches thick, are recommended for spans up to 16 feet in length.

In the typical design shown on page 11 the unsupported span is limited to 16 feet. Longer spans require interior supports — bearing partitions or reinforced concrete beams as shown in Longitudinal Section on page 11. Also, a bearing wall or beam of the same design is required under any first floor partition which carries a load from the second floor.

If required, intermediate bearing walls or beams and columns are built first. Reinforced concrete beams and columns are shown in detail on pages 15 and 17. Posts and stringers for supporting the open centering — the planks which carry the removable forms — are erected next. Removable forms of metal or wood, over which the concrete is placed to form the joists and top slab, are supported on 2 by 6-inch planks.



Floor forms, with steel in place, ready for concreting.

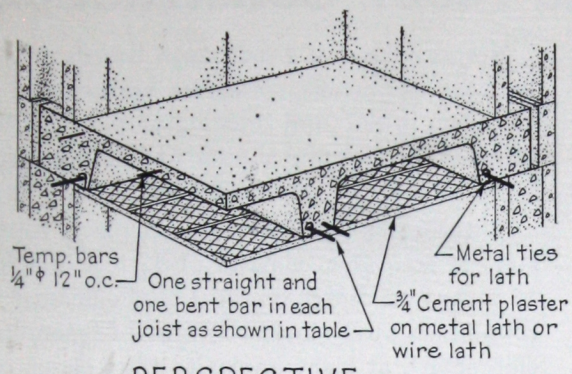
Standard size metal forms or wood boxes of similar design are used. Posts of 4 by 4-inch stock and 2 by 8-inch stringers support the 2 by 6-inch planks. The maximum spacing of posts for an 8-inch concrete joist floor is 6 feet 6 inches. The 4 by 4-inch posts are supported on planks usually of 2 by 10-inch stock, to prevent settling. Hardwood wedges are placed between the base of each post and the plank so that any difference in level may be corrected by adjusting these wedges.

For most spans in residence construction, the 2 by 6-inch planks which support the removable forms and form the joist bottoms are spaced 24 inches on center. Stringers which support these planks are spaced 4 feet apart. Removable forms are lined up with the hollow space down and with sufficient space between rows to permit forming of joists 4 inches wide at the bottom. Forms for concrete joist floor construction are pictured on page 11.

In the space between the rows of removable forms, the main reinforcing steel is placed. The size of the steel for different floor spans is indicated in the table, Reinforcing Bars, on page 11. Two bars are used in each joist, one being bent up 45 degrees, as shown in the Longitudinal Section on page 11, and the other remaining straight. The bars should be supported 1-inch above the plank and ¾-inch from the removable forms on chairs or small pieces of concrete. The ends of the bars are bent so that they are at least 1 inch from the top, bottom and edge of the slab, as shown in the Longitudinal Section. This 1-inch covering of concrete gives the steel protection against possible corrosion or fire. Conduits or pipes are installed or openings provided for them in the floor slab after the main reinforcing has been placed in joist forms.

Temperature reinforcement consisting of ¼-inch steel bars on 12-inch centers is placed at right angles to the joists and ¾ inch below the slab surface. Wire fabric with the same effective steel area per foot at right angles to the joists may be used instead of the ¼-inch bars.

Where plastered basement ceilings are desired, metal lath or wire lath is attached to the under side of the floor by wire ties fastened around the reinforcing and extended through holes in the planks forming the joist bottoms. Nails, driven into the planks so that the heads will be embedded in the concrete, are sometimes used as hangers for the lath. Designing, mixing, placing and curing of concrete and the removal of forms are discussed in detail on pages 22, 23 and 24.



PERSPECTIVE

NOTES

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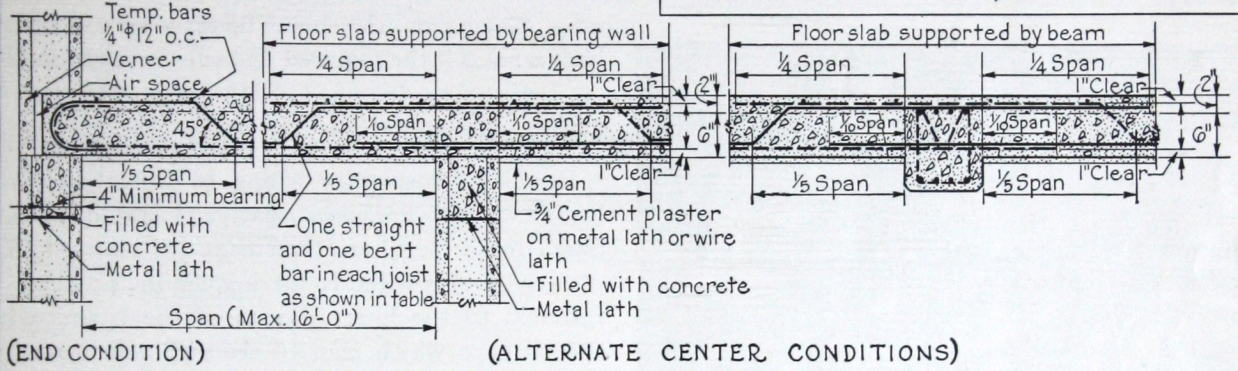
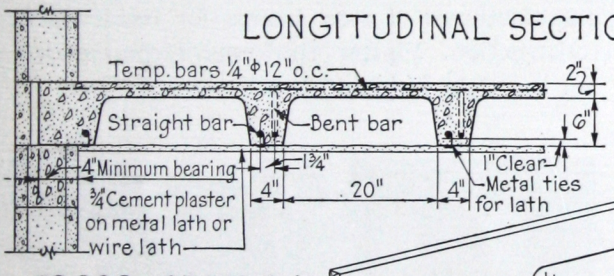
5. Steel reinforcement must be accurately located and held in place. All intersections must be tied with No. 18 annealed wire.
6. Wire fabric with the same effective area per foot may be used instead of temperature bars.
7. Extra reinforcement is required around stairwells

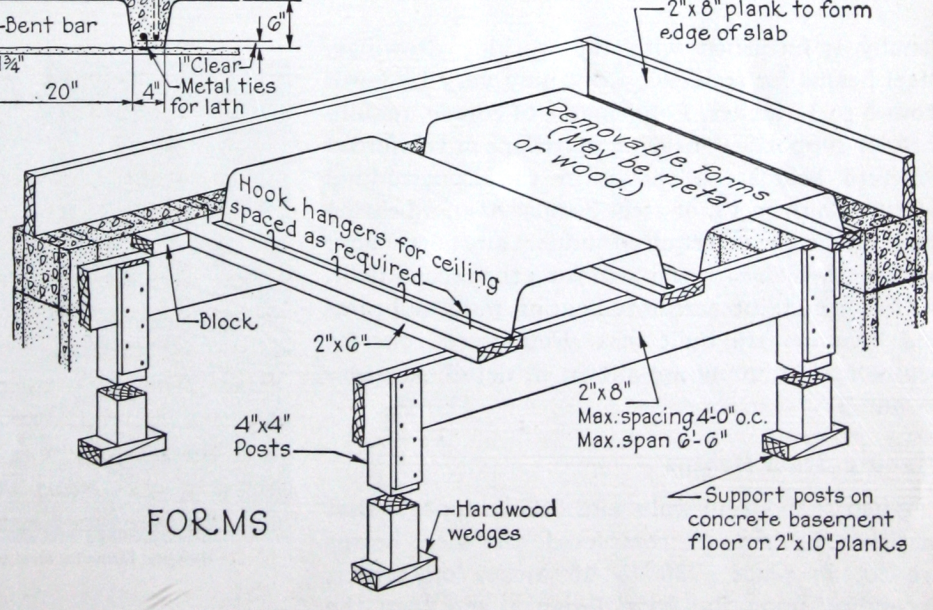


(END CONDITION) (ALTERNATE CENTER CONDITIONS)

LONGITUDINAL SECTION THROUGH JOIST



CROSS SECTION



FORMS

REINFORCING BARS		
Span	Bars per joist	
	Straight	Bent
16'-0" to 14'-0"	1-¾" ϕ	1-⅝" ϕ
14'-0" to 13'-0"	1-⅝" ϕ	1-⅝" ϕ
13'-0" or less	1-½" ϕ	1-½" ϕ

CONCRETE JOIST RESIDENCE FLOOR CONSTRUCTION

Steel Beam-Concrete Floor Construction

A SLAB of reinforced concrete is supported by steel beams in this type of fireproof floor construction for residences. For adequate fire protection, however, the beams should be encased in concrete; or a suspended ceiling, as shown in the drawing on page 13, is built with metal reinforcement and plaster.

Facts About Design

Maximum unsupported span depends upon size of beams and their spacing, information that usually is furnished with the working drawings. Steel beams for residence work may vary in depth from 6 to 12 inches. Long spans, of course, require interior supports — bearing partitions or reinforced concrete beams, as shown in the Longitudinal Section on page 13, or steel beams. Also, a bearing wall or beam is required under any first floor partition which carries a load from the second floor.

Steel beams in place, ready to support simple forming for slab.

If required, intermediate bearing walls or beams and columns are built first. Reinforced concrete beams and columns are shown in detail on pages 15 and 17.

Placing Steel Beams

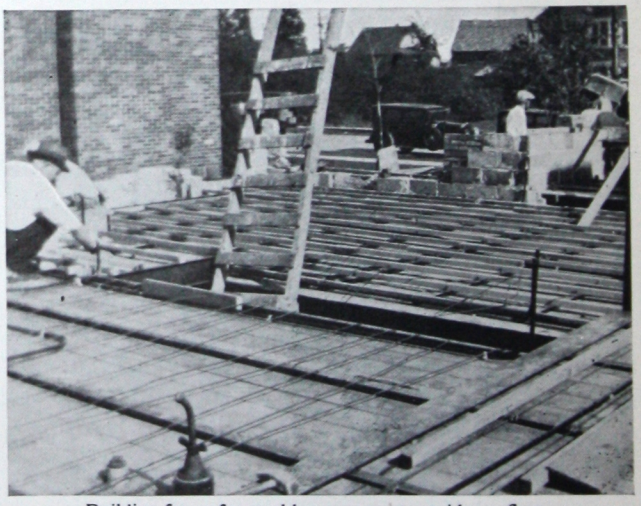
When foundation walls and other supports that may be required are completed, the steel beams are set in place — 30 to 46 inches on center, depending upon the floor design — and then the simple formwork is erected. Steel beams must have a minimum bearing of 4 inches on foundation walls and bearing partitions.

Forms consist of 1-inch form boards or plywood between the beams, spreaders, wedges and planks, as shown in the form drawing on page 13, the construction being quite similar to forming used when precast concrete joist floors are built.

With beams and formwork in place, reinforcing steel is set. This consists of ¼-inch round bars, 18 inches on center, parallel to the beams; ¼-inch round bars 6 to 10 inches on center (depending upon slab span), at right angles to the beams, or large mesh metal reinforcement of equivalent effective area. Placing reinforcement directly on top of the beams holds it the required ¾-inch above the forms.

Ceiling Construction

Building a suspended ceiling, to protect the steel beams against fire, is a relatively simple matter. Small mesh metal reinforcement (to be used as a plaster base) is wired to furring channels which are fastened to the lower flanges of the beams with special clips which usually are available from the manufacturers of steel beams for residence floor construction. Plaster thickness recommended is not less than ¾-inch.



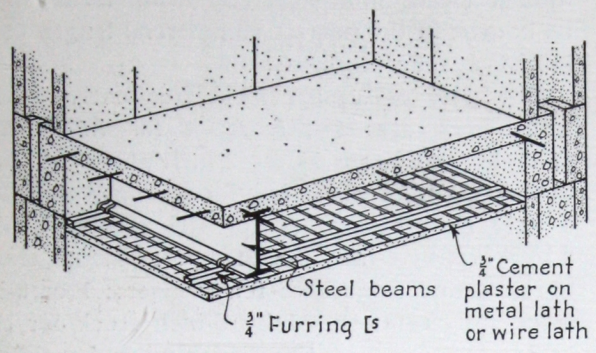
Building forms for steel beam-concrete residence floor.

Designing, mixing, placing and curing of concrete and the removal of forms are discussed in detail on pages 22, 23 and 24.

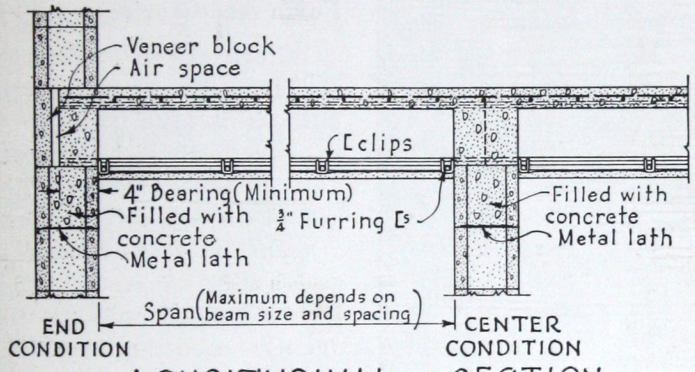
NOTES

1. Concrete shall have a compressive strength of not less than 3000 lb. per sq. in. at 28 days.*
2. Structural floor plans shall conform to the steel beam manufacturer's specifications and shall be approved by the owner's architect. These plans shall show the joist sizes, spacing and other framing details; slab thicknesses and reinforcement.
3. Design loadings shall conform to those recommended by the Building Code Committee-U.S. Dept. of Commerce and/or the local building regulations.
4. Bearing partitions must be carried by walls or by beams and columns below.
5. Concrete forms shall be built so that the bottom of the concrete slab will be approximately 1" below the top of the steel beams.
6. The steel beams should be fireprotected on the underside by concrete encasement or a suspended portland cement plaster ceiling.

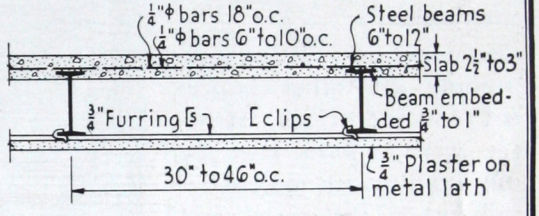
*(7½ gal. of water per sack of cement)



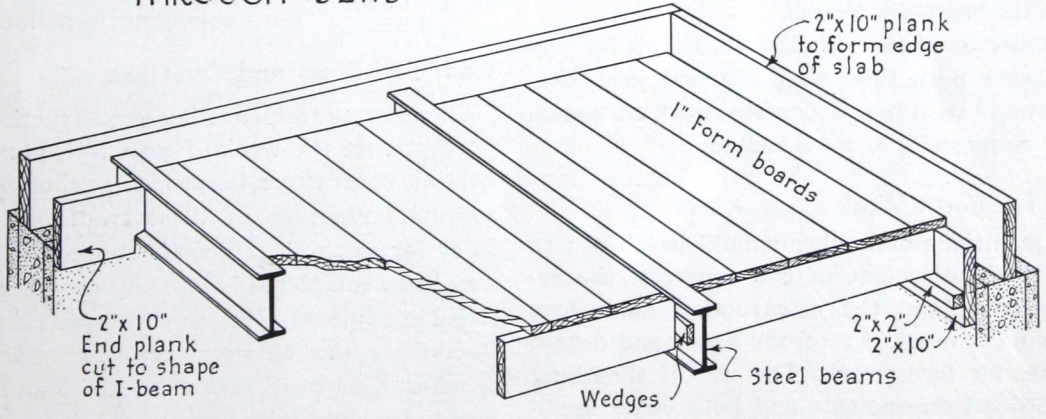
PERSPECTIVE



LONGITUDINAL SECTION THROUGH SLAB



CROSS SECTION



FORMS

STEEL BEAM - CONCRETE RESIDENCE FLOOR

Form Construction

SIMPLICITY is a primary requirement in form construction. Forms must be strong enough to carry safely the weight of the concrete plus the live load which must be sustained during concreting. Durability is also essential as forms should be able to withstand hard and repeated usage. Proper bracing is necessary to prevent possible bulging and sagging. Economy of construction and material, consistent with strength, is also desirable. To prevent seepage through cracks, it is important that forms be close-fitting. Seepage causes ridges and honeycombing which can be eliminated by proper form construction.

Economy in erecting and stripping are other important considerations. However well a form may be built, its ultimate success depends upon the speed and ease with which it can be erected and stripped. Further economy is effected by designing forms so the lumber can be used again.

Column, beam and joist forms.

Forms for basement beams and columns are shown on page 15. Forms for precast concrete joist, solid slab, tile and joist, concrete joist and steel beam-concrete floors are shown in detail on pages 5, 7, 9, 11 and 13.

Lumber for Form Work

The dimensions of lumber should be chosen to carry safely the weight of the concrete, the reinforcing steel, and the construction load. Any good, sound lumber, free from knots and decay, is suitable for form work. The use of sheathing lumber dressed on one side and both edges facilitates removal of forms. Where smooth, true surfaces are required, the lumber should be dressed on all four sides. Tight joints may be obtained by using tongue-and-grooved stock or shiplap.

Thickness of lumber depends somewhat upon the number of times the forms will be used and, in the case of floor forms, on whether the boards are to be built into panels or nailed each time to the supporting timbers. To minimize waste, lumber for column, joist and beam forms should be bought in the nearest commercial length to the height or span required.

The sizes of lumber most frequently used in form work are: 1-inch stock for floor forms, columns and beam sides; 2-inch stock for beam bottoms; 2 by 4-inch stock for column yokes; 2 by 6 or 2 by 8-inch stock for stringers and joists; 3 by 4 or 4 by 4-inch stock for posts, struts, shores, uprights and sometimes for stringers; 1 or 2-inch stock for cleats; and 1 by 6-inch stock for cross ties and similar bracing.

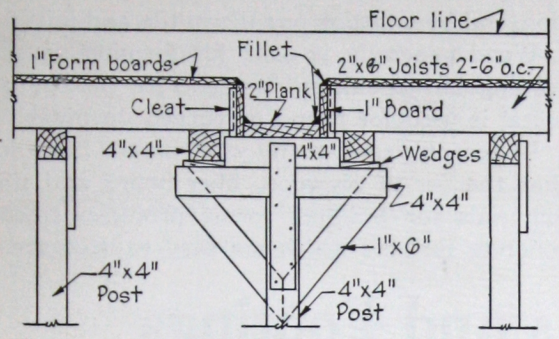
Form Accessories

Where several concrete residence floors are to be built, it is usual practice to procure adjustable shores and column clamps. The use of these devices effects a saving in form lumber as well as in carpenter work. Double-headed nails are frequently used because they can be drawn easily when stripping the forms or when salvaging form lumber.

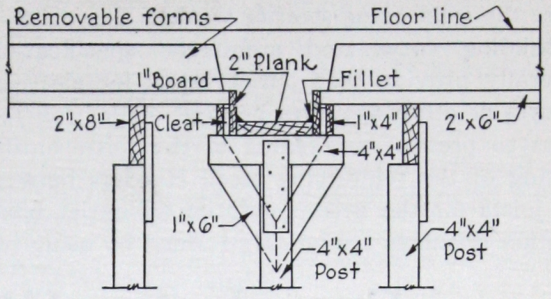
Conduits, Pipes and Openings

In concrete residence floor construction it is important that the work of electrical, plumbing and heating contractors be properly scheduled to the mutual advantage of these trades. Their work, in so far as the first floor is concerned, ordinarily should be completed before any concrete is placed.

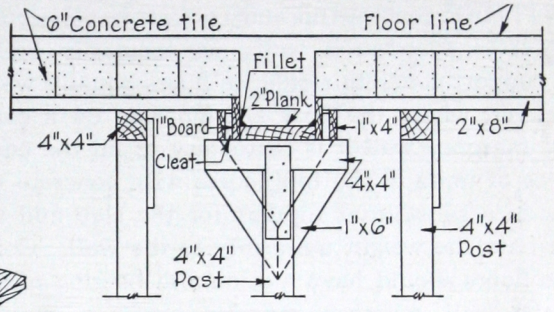
All conduits or pipes should be so located as not to reduce the strength of construction. Where structural concrete floors are to be surfaced with wood flooring, pipes or conduits usually are placed between the sleepers. When other types of floor finishes are to be used, conduits or pipes are placed in the top slab of concrete joist or tile and joist floors and in the bottom of solid slab floors, usually just above the reinforcing steel. In concrete joist floor construction, pipes or conduits may be placed in the open space between joists. In any event, conduits or pipes never should be



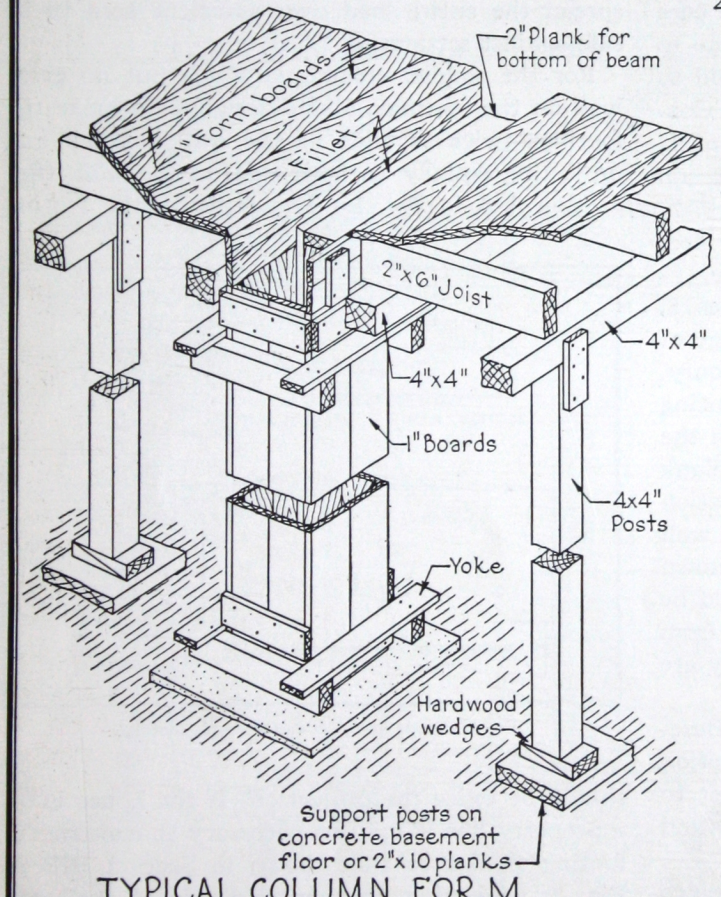
CROSS SECTION OF BEAM FORM
(SOLID SLAB FLOOR)



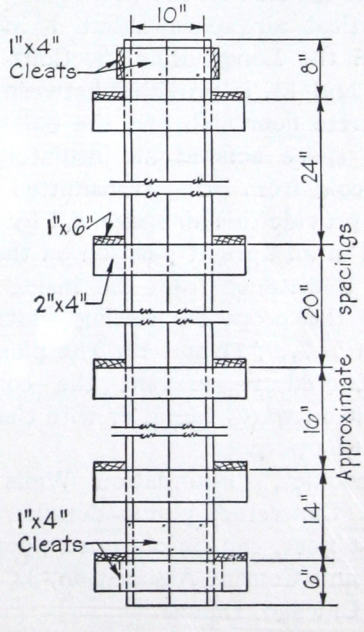
CROSS SECTION OF BEAM FORM
(CONCRETE JOIST FLOOR CONSTRUCTION)



CROSS SECTION OF BEAM FORM
(TILE AND JOIST FLOOR)



TYPICAL COLUMN FORM
SHOWING FORMS FOR
SOLID SLAB FLOOR



SPACING OF YOKES ON
TYPICAL COLUMN FORM

BEAM AND COLUMN FORMS FOR CONCRETE RESIDENCE FLOORS

placed in the joists as such construction will displace the reinforcing steel or weaken the joists.

Building codes and architects' specifications generally provide that outlet boxes for electrical fixtures or other openings be kept out of concrete joists to prevent weakening of the joists or displacing of the reinforcing steel. Headers between the joists for the accommodation of outlet boxes or other openings are quickly formed by using two straight end forms in concrete joist floor construction, and by omitting one tile in tile and joist floors.

Wood generally is used for forming square or rectangular openings in concrete floors; sheet metal is used for round or curved openings.

In recent years, many contractors have found that the use of plywood, fiber board and similar materials for building forms produces smoother concrete surfaces which are easy to decorate.

Foundation Walls and Footings

EITHER concrete masonry or cast-in-place concrete foundation walls, as ordinarily built, will support concrete residence floors equally well. However, where the floor is supported on a concrete masonry wall it is customary to fill the core spaces of units in the top course with concrete to provide a substantial support for the slab and to distribute the weight uniformly to the wall. Concrete floors should have a minimum bearing of 4" on the wall, whether concrete masonry or job placed concrete. If the wall is 12 inches thick, 7" bearing of the slab on the wall usually is provided.

A vertical air space about 1 inch wide, as shown in the Longitudinal Sections on pages 5, 7, 9, 11 and 13, is provided between the edge of the concrete floor slab and the outside masonry. This air space acts as an insulator, preventing heat or cold from being transmitted through the slab. To provide this air space, a 2 by 8-inch plank is placed in an upright position on the foundation wall, at a distance from the inside of the wall equal to the proposed bearing width, as shown on pages 5, 7, 9, 11 and 13. The plank should be well anchored to prevent the concrete from pushing it outward. Metal or wire ties usually are used for this purpose.

The booklet, "Foundation Walls and Basements of Concrete," giving detailed information on this subject, can be obtained upon request to the Portland Cement Association, 33 West Grand Avenue, Chicago, Illinois.

It is common practice to place cast-in-place concrete footings for columns and bearing walls which support concrete floors. Such footings provide an even surface on which to start the wall, whether it is built of concrete masonry or cast-in-place concrete. Also they provide increased bearing area on the soil, thus insuring against settlement. In determining the width of footings, the character of the soil as well as the weight of the house and its contents must be taken into account. The footing should be made wide enough to spread the entire load over sufficient area to be safe against settlement.

For the smaller structures which put no great load on the footings, a safe design is to make the footings twice as wide as the wall is thick and projecting equally on both sides of the wall. (See Section A-A in Fig. 1.) The depth of the footing

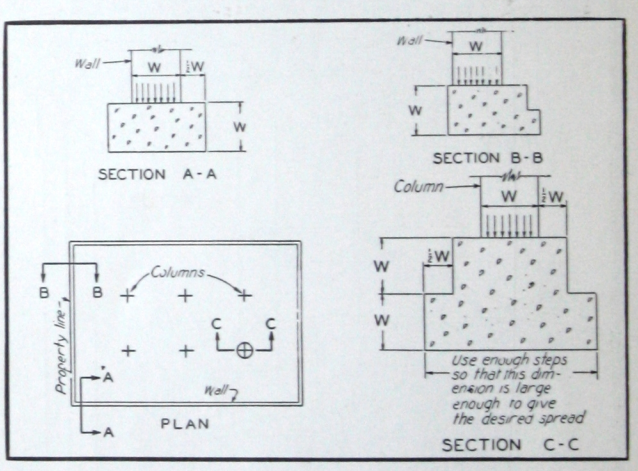
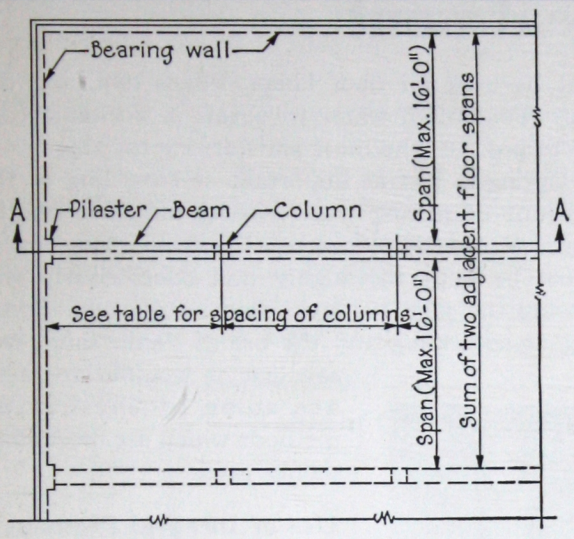


Fig. 1. Guide for the design of simple footings.

should be twice the projection. If the house is on a property line it may be necessary to construct a footing similar to that shown in Section B-B of Fig. 1, projecting only on one side of the wall. Under heavily loaded columns the footings are "stepped down" as shown in Section C-C of Fig. 1. Note that the projection is one-half the column thickness, and that the depth of each step is twice its projection. "Stepping down" of footings saves concrete, yet gives the desired spread.



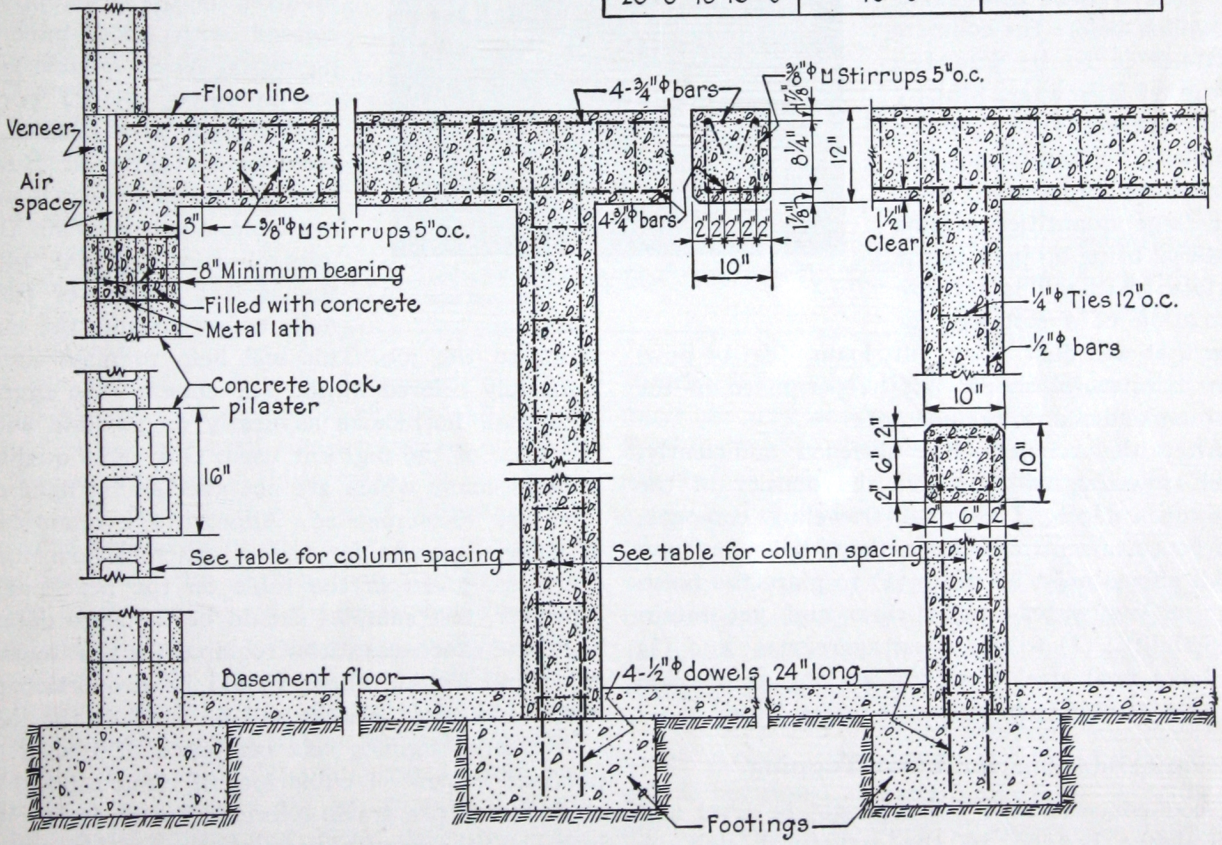
TYPICAL LAYOUT OF BEAMS AND COLUMNS

NOTES

1. Designed for concrete with a compressive strength of not less than 2000 lb. per sq. in. at 28 days (7½ gal. of water per sack of cement.)
2. Designed according to Building Regulations of the American Concrete Institute, 1928.
3. Loadings are those recommended for Residences by the Building Code Committee of the United States Department of Commerce.
4. Steel reinforcement must be accurately located and held in place. All intersections must be tied with No. 18 annealed wire.

MAXIMUM SPACING OF COLUMNS C. TO C.

SUM OF TWO ADJACENT FL. SPANS	FOR A TWO STORY HOUSE	FOR A ONE STORY HOUSE
32'-0" to 28'-0"	8'-6"	10'-0"
28'-0" to 24'-0"	9'-0"	10'-6"
24'-0" to 20'-0"	9'-6"	11'-6"
20'-0" to 16'-0"	10'-0"	12'-6"



SECTION A-A SHOWING REINFORCEMENT OF BEAM AND COLUMNS

BEAMS AND COLUMNS FOR CONCRETE RESIDENCE FLOORS

Surface Treatment

SURFACE treatment of concrete residence floors involves several processes including the use of mineral pigments, stains and paints to develop color. These treatments may be applied directly to the structural concrete slab, troweled smooth, or to concrete floor toppings.

Troweled Concrete Floor Finish

Smoothness is one of the first essentials of a concrete residence floor finish. The most common and economical method for obtaining a smooth concrete surface is steel troweling.

Concrete finish marked off to resemble tiling.

Troweling, a very important operation, deserves full consideration. Excessive troweling before the concrete stiffens is to be guarded against. Likewise, sloppy consistencies are to be avoided. An excessively wet mix cannot be troweled without large quantities of fine material being brought to the surface, which will later cause formation of a soft skin or film that will dust. Clay, silt, loam, dust or powdery admixtures should not be permitted in the topping under any circumstance.

After the concrete has stiffened sufficiently, steel troweling will improve the density of the wearing surface. This final troweling compacts the concrete and provides a tight, dense surface.

All efforts must be made (1) to place the finish with a low water-cement ratio and yet retain workability; (2) to use clean aggregates; and (3) to delay final steel troweling as long as possible and yet be able to produce the proper finish.

Recommendations for Floor Topping

Good concrete floor finish should be level and thoroughly bonded to the structural slab. A topping mix composed of 1 sack of portland cement, 1 cu. ft. of torpedo sand and 2 cu. ft. of pea gravel or crushed stone ($\frac{1}{8}$ to $\frac{3}{8}$-inch) is satisfactory. Sand containing more than 15 per cent of material passing a 50-mesh sieve should not be used for floor finish. Mixes requiring the least amount of water to obtain a workable concrete produce the most satisfactory topping.

Curing is just as important as troweling or the amount of mixing water, in its influence on the quality of the concrete. Concrete floor finish must be kept thoroughly and continuously wet during the first 10 days after installation. Ponding or sprinkling and the use of damp sand, wet sawdust or wet burlap sacks are some of the curing methods which are most commonly used.

Use of Integral Pigment

This type of color finish involves the use of a topping colored with good mineral pigments. Where reliable factory-prepared colored portland cement is available, it is recommended for use. However, if colored cement is not available, it is best to mix the mineral color pigment with the cement in ball or tube mills before sending the material to the job. This will help to maintain a uniformly colored finish. The color of the aggregate shall harmonize as nearly as possible with the color of the pigment used. Only first quality mineral colors which are not affected by light or lime are recommended. Approximate quantities of color pigments for use in concrete floor toppings are given in the table on the next page. However, test samples should be made to determine the exact quantities required for the desired color and shade. These should be proportioned, mixed and cured just as will be done on the job.

A colored topping mix composed of 1 sack of portland cement, 1 cubic foot of clean sand, $1\frac{1}{2}$ cubic feet of pea gravel or crushed stone ($\frac{1}{8}$ to $\frac{3}{8}$-inch,) and the required amount of mineral pigment, is recommended. Then add just enough water (not more than $4\frac{1}{2}$ gallons) to obtain a plastic, quaky mix that holds together well. Mix the concrete thoroughly for two minutes after all materials have been placed in the mixer.

Where color is not needed all the way through the topping, or where lower cost is important, the finish may be placed in two layers. The bottom layer of the topping, without color, is placed to within ¼-inch of the finished floor thickness and struck off level. The colored finish is then placed immediately. Early troweling should be limited to a minimum and the final troweling delayed as long as possible and yet be able to produce the proper finish. Variations in color due to trowel shading are to be avoided. Experienced finishers who are familiar with color work should be employed to do the finishing if possible.

In residential floor construction the colored finish usually is applied to a structural slab already hardened. In this case the structural slab should be left rough. Before applying the topping, the concrete should be cleaned, dampened, and just before placing the new concrete the old surface should be painted with cement and water mixed to the consistency of thick cream. A top finish of not less than ¾-inch is used, whether it is placed in two layers or one.

As soon as the surface has hardened sufficiently to prevent injury, the finish should be protected against staining and other possible injury by covering with 1 inch of clean, wet sand or approved concrete curing paper. None of these coverings should contain any material that will stain the floor finish. The covering is kept wet for 7 days, and should not be removed until all trades have completed their work. When the finish is clean and dry, it usually is waxed with any standard floor wax. The wax should be applied evenly and preferably rubbed with a power-operated polishing machine. Oil or polish can be used instead of wax, if desired, for finishing.

Table of Colors to Be Used in Concrete Floor Finish

COLOR DESIRED	Commercial Names of Colors for Use in Cement	Pounds of color required per sack of cement to secure Light Shade	Med. Shade
Grays, blue-black and black	Germantown lampblack* or	½	1
	Carbon black* or	½	1
	Black oxide of manganese* or	1	2
	Mineral black*	1	2
Blue shade	Ultramarine blue	5	9
Brownish-red to dull brick red	Red oxide of iron	5	9
Bright red to vermillion	Mineral turkey red	5	9
Red sandstone to purplish-red	Indian red	5	9
Brown to reddish-brown	Metallic brown (oxide)	5	9
Buff, colonial tint and yellow	Yellow ochre or	5	9
	Yellow oxide	2	4
Green shade	Chromium oxide or	5	9
	Greenish blue ultramarine	6	..

*Only first quality lampblack should be used. Carbon black is light and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds oxide per sack of cement.

Factory-mixed floor toppings, consisting of portland cement, mineral color pigment and the required aggregate, are recommended when procured from reliable manufacturers. These require only the addition of water and thorough mixing and careful placing on the job.

Staining Process

Staining concrete with inorganic dyes produces a mottled, beautifully mellow effect. Staining is done after the concrete topping has dried out. The surface must be free from oil, plaster, lime or other stains. Directions of inorganic stain manufacturers for preparing a concrete floor topping or surface for the staining process must be closely followed.

Painting Concrete Floors

Before painting a concrete floor it is necessary to remove all dirt and to neutralize the surface by brushing on a solution of zinc sulphate. The solution, 4 pounds of zinc sulphate dissolved in 1 gallon of clean water, may be applied with paint brush, mop or squeegee after the concrete has become thoroughly dry. Before applying paint, the surface should be allowed to dry for at least 48 hours and then be brushed to remove zinc sulphate crystals and dust.

The work is similar to painting the ordinary wood surface. The results of tests show that paints composed of pure linseed oil or of hard drying varnish, in which is suspended abrasion-resisting pigments of the desired color, give excellent results. The first coat should be diluted with turpentine or other suitable thinner to get good penetration. The second and third coats are applied without being diluted.

Hard Surfaces

IN the group of hard surfacings are included terrazzo, concrete tile, art marble, ceramics, marble mosaics and slate. Great freedom in design and color is now possible with all of these materials, assuring floors that not merely supplement, but frequently dominate the beauty of interior decoration and design.

Terrazzo Floor Finish

A terrazzo floor consists of a concrete structural slab, a mortar base, and a wearing surface or topping containing a high percentage of marble chips or other selected aggregate. The best practice calls for a combined base and surface thickness of 2 inches.

The mortar base for terrazzo is bonded to the structural concrete floor slab. The base course should be a 1:4 mix, using clean, coarse torpedo sand, and should be screeded to an even surface about $\frac{5}{8}$ inch below the finished floor level.

Concrete tile laid over concrete floor produce an attractive finish

Metal dividing strips of brass or white metal, $1\frac{1}{4}$-inch wide and at least 20 gauge in thickness, are placed the entire length and breadth of the floor not to exceed 5 feet on centers so that the top edges of the strips are slightly above the level of the finished floor. These strips are required in all terrazzo.

In the wearing surface, the aggregates are usually stone chips in three sizes. The mix is usually one part portland cement to two parts of aggregate selected to match samples approved by the architect or owner. The mix is placed in the spaces formed by the dividing strips and rolled in a compact mass until all excess cement and water is extracted. The surface is then thoroughly floated and troweled to a close uniform texture and even surface. The terrazzo is kept moist until finishing is completed.

When the surface is sufficiently hard, it is machine ground with coarse abrasive stones and then grouted with a colored neat cement paste to match the terrazzo mix and to fill any small voids on the surface. Not less than 72 hours after the floor has been grouted, it receives a final fine grinding and is then washed thoroughly with a neutral soap. The floor is then machine polished with a soap emulsion or other polishing compound.

Other Hard Surfaces

When surfaces of concrete tile, art marble, ceramics, marble mosaics or slate are desired, the following should be used as a guide:

The rough concrete floor is brought to within 2 or $2\frac{1}{4}$ inches of the desired level of the finished floor. The portland cement mortar for laying tile should be a 1:3 mix. Before the tile are laid they should be soaked in water for 10 to 20 minutes and then allowed to dry about the same length of time; the object being to have them uniformly damp, but never dripping wet.

Laying of the tile should begin in the center of the room so that opposite sides will require the same number of tile. This includes the full width outer border, if one is desired, and if any space is left, it should be filled with solid color tile to match the border. These should be cut to fit, except when the space is 1 inch or less in width. In this case it is best to fill the space with a well-mixed mortar made of equal parts of portland cement and fine sharp sand, colored with pigment to match the border. (See information on Surface Treatment, pages 18 and 19.)

Concrete tile, art marble, ceramic tile, marble mosaics and slate usually are laid with joints ranging from 1-16 to $\frac{1}{2}$ inch. It is recommended that directions for laying, given by manufacturers and distributors of these floor surfacing materials, be followed closely.

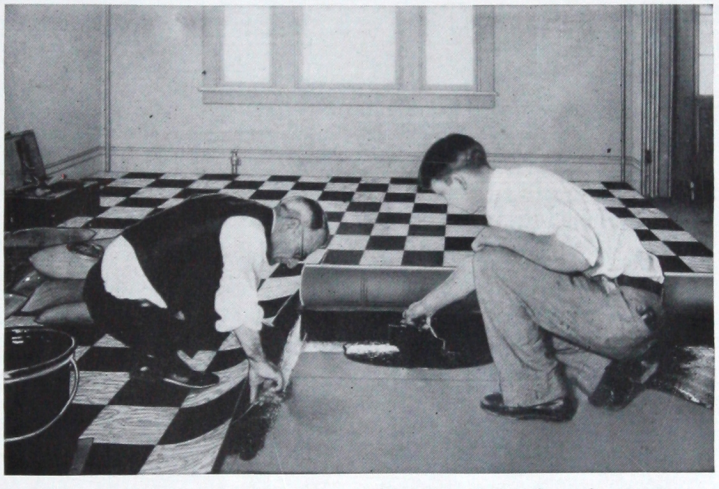
Linoleum, Carpet and Other Coverings

PLAIN, inlaid, jaspe or embossed linoleum, rubber or cork flooring or tile, and carpet are common types of floor coverings. These coverings, with the exception of carpet, are cemented to the concrete. The structural slab usually is satisfactory.

In every case, manufacturers' specifications for preparing the surface and instructions for laying the floor material should be followed carefully.

Linoleum Flooring

Where linoleum is to be laid, the concrete floor should be screeded and steel troweled to a true, even surface. All surface irregularities should be removed. The concrete floor must be finished below the desired floor level, the thickness of the floor covering specified. Admixtures, hardeners, paints or surface coats of any kind are not recommended. The concrete floor must be clean, "bone-dry," and free from foreign material. A simple test for moisture in concrete may be made by placing pieces of linoleum face down on the floor — one at each corner of the room and another near the center, weighting the edges. After about 24 hours remove the weights and linoleum. If the floor is not entirely dry, the face of the linoleum and the floor itself will appear slightly damp.



Linoleum and similar floor coverings can be cemented directly to the concrete.

Linoleum may be cemented directly on concrete floors without the use of deadening felt, if the surface is troweled to a smooth finish and the extra resilience of the felt lining is considered unimportant. Solid colors of battleship linoleum are laid so that the edges overlap, and both thicknesses of the lap are cut at one time. Cutting through both thicknesses on a bevel provides an especially close joint. This method of jointing is not used with pattern linoleums.

Linoleum should be thoroughly rolled after laying, especially at joints. Sand bags or weights should be used to hold down these joints until the cementing material has fully set.

Cork or Rubber Floor Coverings

Where cork or rubber tile or flooring are to be laid, the concrete floor finish should meet the same requirements as for linoleum coverings. Here, again, the floor must be finished below the desired floor level, the thickness of the floor covering specified. The concrete floor must also be clean "bone-dry," and free from foreign material.

It is best to submit a floor plan to the floor covering manufacturer for advice on the pattern layout and recommendations for best method of laying the material.

Coverings of Carpet

At the time the floor is placed, wooden carpet strips, usually 1 by 2-inch lumber, should be embedded in the concrete around the border of the room. The surface of the floor is screeded and troweled flush with these strips. The finish should be about the same as for rubber or linoleum floor coverings; a smooth, even surface being desired. What is usually described as "sidewalk finish" is satisfactory.

To prolong the life of the carpet and at the same time add to its resilient and sound-proofing qualities, a carpet padding or cushion may be placed on the concrete floor before the carpet is laid. It is a simple matter to stretch the carpet and tack it firmly to the wooden strips around the border of the room.

Wood Surfaces

WHERE wood surfaced floors are desired in residences, any type of hardwood — maple, birch, beech or oak — can be laid over the structural concrete floor. Such practice is common in living and dining rooms, and floors so laid will not sag, creak or become warped.

Wood flooring is nailed to sleepers fastened to concrete floor with clips.

The standard method of laying hardwood flooring over a structural concrete floor slab is to nail the boards to 2 by 2 or 2 by 3-inch sleepers. These sleepers may be embedded in the top part of the slab, held in place by a fill of cinder or other lightweight concrete, or fastened to metal or wire clips embedded in the concrete.

If the sleepers are embedded in the slab at the time the concrete is placed or if they are held in place with cinder concrete, they should be of bevelled stock. In any case, the sleepers should be placed not over 16 inches on center; preferably 12 inches in residential construction.

Before hardwood flooring is nailed to the sleepers, the concrete floor must be thoroughly hardened and free from moisture. It is also best to delay laying hardwood floors until after the plasterers have finished work.

Where hardwood flooring is to be laid over concrete on a wet fill or below grade, the structural floor should be waterproofed by an impermeable membrane placed within the slab. However, a creosoted underfloor and two layers of waterproof paper may be used in place of the membrane where moisture conditions are not too severe. Either method is common practice.

Certain types of parquet and design wood floorings are laid directly on the concrete. The surface should be troweled smooth and be free from moisture. No special topping is required, the ordinary level "sidewalk finish" providing a satisfactory base. The flooring is bonded to the concrete with bituminous cement. Manufacturers' directions for laying this type of wood flooring should be followed carefully, in order to insure satisfactory results in the finished floor.

Fundamentals of Good Concrete

Portland Cement

Portland cement is a thoroughly dependable product. All of the standard brands produced by members of the Portland Cement Association are tested regularly and will produce good concrete when properly combined with the other materials necessary for a concrete mixture.

Aggregates

Aggregates for making concrete (sand and coarse material) should be clean, hard and free from fine dust, loam, clay or vegetable matter. In general, the maximum size of aggregates is governed by the nature of the work. For concrete floors, beams and columns, sand should be graded from fine up to ¼-inch, while coarse aggregate should be graded in sizes ranging from ¼-inch up to ¾-inch.

The natural mixture of fine and coarse aggregate as taken from the gravel bank or crusher seldom is suitable for concrete unless first screened to separate fine material from the coarse and then recombined in the correct proportions. Such material must also be washed thoroughly.

Mixing Water

Strength, water-tightness and durability of concrete are controlled by the amount of water used per sack of cement. The inclusion of too much mixing water thins or dilutes the cement paste and weakens its cementing qualities. It is therefore important that the correct amount of mixing water be used to obtain concrete of the required strength and density according to the class of construction for which it is intended.

Aggregates usually contain some moisture. Sand, for example, may be damp, wet or very wet, containing about ¼, ½ and ¾ gallons of water per cubic foot, respectively, that is free to act on the cement. Therefore, it is necessary to consider this moisture as part of the mixing water. Estimated amount of water contained in sand should be deducted from total number of gallons specified.

Concrete for Floors, Beams and Columns

For residence floors, beams and columns, concrete which attains a compressive strength of not less than 2,000 pounds per square inch at 28 days is required. A mix for 2,000-pound or stronger concrete is one containing not more than 7½ gallons of water (with aggregates that are dry) for each sack of portland cement. Use only 6¾ gallons with damp sand; 6¼ gallons with wet sand; and 5 gallons with very wet sand.

As a trial batch combine 1 sack portland cement, 2½ cu. ft. sand and 3½ cu. ft. coarse aggregate (1:2½:3½ mix), using quantities of water specified. If this produces a mixture that is too wet, add more sand and coarse aggregate. If too stiff a mix results, use less aggregate in succeeding batches. Do not vary the amount of water from the amounts specified.

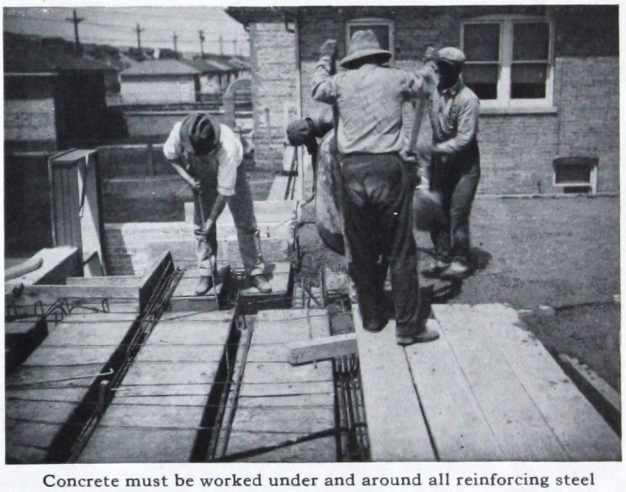
Workable Mix

A workable mix is one that can be placed readily in the forms without separation of ingredients, and that with spading or tamping will fill all angles and corners of the forms. In a workable mix there is sufficient cement-sand mortar to give smooth surfaces, free from rough spots (called honey-combing), and to combine the pieces of coarse aggregate into a mass that will not separate out in handling. In proportioning sand and coarse aggregate, amounts of each may be varied as required to produce a workable mix, but total quantity of water should be used exactly as specified to obtain the desired strength.

Placing Concrete in Forms

After the concrete has been mixed thoroughly, preferably by machine, it is deposited in the forms in layers and in a continuous operation, if possible, to avoid construction seams. The concrete should not be so stiff that it requires excessive puddling to get it to settle into the forms. Spading is the common method of working the concrete next to form faces to obtain smooth, even surfaces. This operation pushes large aggregate away from the surface and releases any air that may have been entrapped when the concrete was placed. The concrete should be thoroughly worked around all reinforcement, around embedded fixtures, and into the corners of forms.

It is well to complete the work in one day's operation, if possible, in order to avoid construction seams. For construction other than floors, if it is necessary to stop placing concrete before the work can be finished, the concrete should be leveled in the forms and the surface roughened. This will help to secure a good bond between old and new layers of concrete when work is resumed. When there has been more than one day's delay or after a heavy rain, the roughened surface should be scrubbed with clean water to remove any dirt or scum, and just before placing new concrete the old surface should be painted with a grout of portland cement and water mixed to the consistency of thick cream.



Concrete must be worked under and around all reinforcing steel

Concrete residence floors should be placed the full thickness and concreting should progress parallel to joists or main reinforcing steel. The work should be completed in one day's operation. However, if it is necessary to stop work, construction joints in floors should be located near the middle of spans and at right angles to the joists or main reinforcing steel. At least two hours must elapse after depositing concrete in the columns or walls before placing concrete in beams or slabs supported thereon.

Removal of Forms

Forms usually may be removed as soon as the concrete has hardened sufficiently to be self-sustaining. When the temperature is above 60 degrees F., the minimum time for removing forms after placing concrete should be as follows:

Forms for footings, basement walls or foundations, 1 day; forms for the sides of beams, 2 days; column forms, 3 days; forms for floor slabs of spans up to 16 feet, 6 days; beam shores, 6 days.

Building materials or equipment should not be allowed on the floor until supports or shores are replaced immediately after the forms are removed. Supports should then be left in place under floor slabs at least 2 weeks; under beams, at least 3 weeks, and at least 2 weeks longer when under floors carrying weight of building operations.

When the temperature is below 60 degrees F., the forms and supports or shoring should be left in place a longer period, depending upon the weather encountered. Ordinarily, one week is sufficient extra time for cold weather work.

Placing concrete for floor. Pipes are installed and forms provided for openings.

Curing Concrete

Moisture and heat are necessary for the proper hardening of concrete. If this fact is kept in mind, no difficulty will be encountered in effecting proper curing. It is recommended that structural concrete floor slabs be kept continually wet for 10 days. This also applies to toppings.

Cold Weather Concreting

Concrete may be placed safely in cold weather if the fact is kept in mind that heat hastens and cold retards hardening of concrete. Winter concrete work, whether cast-in-place or masonry, is successful if all materials are heated to remove frost before they are used and the finished work protected against freezing until it has hardened sufficiently to resist frost action.

The concrete should be placed at a temperature which will not delay the initial hardening process. The temperature of the concrete should be not less than 70 degrees F. when placed in the forms, and not above 100 degrees F. It is advisable to heat both aggregates and mixing water in severe cold weather. The maximum temperature should not be such as to produce too rapid evaporation of moisture.

Tarpaulins of canvas are most convenient for protecting concrete in cold weather. When the weather demands that the work be heated, the use of salamanders is the usual method for supplying heat. It is best to maintain a minimum temperature of 60 degrees F. within the enclosure for 5 days. During protracted cold weather keep the tarpaulins up and maintain a temperature of not less than 40 degrees F. for 10 days additional.